# Application of Analytic Hierarchy Process in Comprehensive Evaluation Index of Urban Amenity

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**Abstract:** This paper develops a comprehensive urban amenity evaluation index system applicable to cities through the connotation of the concept of urban amenity, focusing on indicators of key significance in the comprehensive urban amenity evaluation system. Based on this, an empirical study of urban amenity in Jiangsu, China was conducted using AHP hierarchical analysis. We took Jiangsu as the study area and constructed a comprehensive evaluation system for urban amenity in Jiangsu. The calculated comprehensive urban amenity evaluation scores can provide experiences for cities to improve their ability to attract talents and develop urban competitiveness.

## 1. Introduction

Talents are the precondition for the rapid development of the regional economy, and the gathering of talents in the region is the key factor to promote the development of the urban economy. As the driving force of urban growth, urban amenity does not directly affect urban development, but indirectly promotes urban development by attracting talents [1]. Innovation has become an important driving force for economic growth, and innovative talents are the most critical element of innovative economic development [2]. In the context of economic globalization, urban amenity is particularly attractive to innovative and highly educated people, and as a means to promote urban development and enhance the competitiveness of cities.

With socio-economic progress, the spatial distances between cities are shrinking, and highly educated people are freer to choose where to move and demand a better quality of life. Social environment factors such as recreation, lifestyle, and local characteristics are gradually replacing purely economic factors as important factors in attracting talents. In the current context of the transformation of China's cities from a traditional industrial economy to the knowledge economy and service economy, as well as the construction of new urbanization, it is of great theoretical and practical significance to systematically carry out urban amenity research. The economic development speed of Jiangsu has accelerated and the level of urban development has improved, making it rank the top level of urban development in China. Therefore, it is of great significance to carry out a comprehensive evaluation of urban amenity in Jiangsu and conduct in-depth cooperative research on this topic in multiple disciplines and fields for the development of Jiangsu cities and the improvement of Jiangsu's urban competitiveness. This paper constructs a comprehensive evaluation system for urban amenity in Jiangsu and analyzes the reasons for the spatial differences in urban amenity in Jiangsu. On the one hand, it can provide a basis for decision-making for the transformation of Jiangsu cities from traditional cities to innovative cities. On the other hand, it also provides suggestions for Jiangsu cities to improve their urban amenity level and attract talents, thus improving their competitiveness.

## 2. Overview and Theoretical Basis

In the context of the knowledge-based economy, urban amenity contributes significantly to the economic development of cities by attracting talented people, especially innovative ones, as well as by attracting businesses to cities. Scholars mainly evaluate urban amenity in terms of natural and artificial environments [3,4]. The natural environment is determined by the location of the city, while the artificial environment includes historical and modern facilities with aesthetic value and a social atmosphere.

In the West, there is a growing interest in the comfort of the social environment, especially inclusiveness. The main research methods used by Western scholars include standard sociological research methods, such as questionnaires and interviews, and structural equation modelling [5,6]. In this paper, we take Jiangsu, China (Figure 1), as the research object, construct an urban amenity index system, calculate the urban amenity index weights based on experts' scoring of each index, and calculate the comprehensive urban amenity evaluation index based on the derived weights. Then, we use ArcMap software to draw the urban amenity rating map of Jiangsu based on the comprehensive urban amenity evaluation index, analyze the reasons for the spatial differentiation of urban amenity, and provide suggestions for urban development.

## 3. Methodology

### 3.1. Study Area

The study area includes 13 prefecture-level cities in Jiangsu Province as follows: Nanjing, Xuzhou, Wuxi, Changzhou, Suzhou, Nantong, Huai'an, Yancheng, Yangzhou, Zhenjiang, Taizhou, Suqian, and Lianyungang (Figure 1).

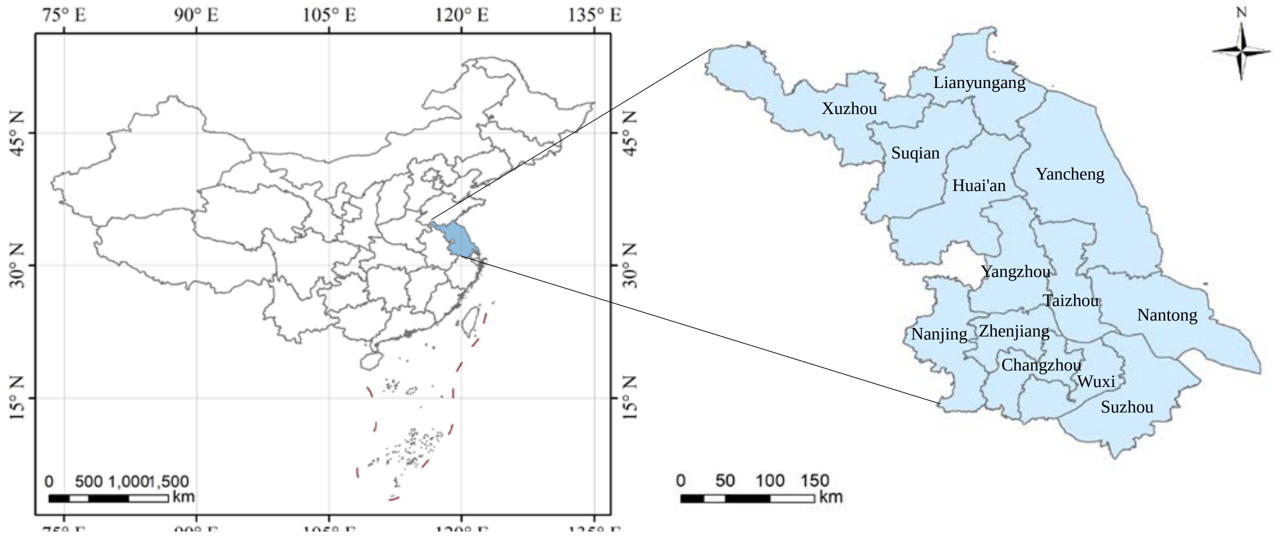


Figure 1 Study area.

### 3.2. Research Methods

AHP hierarchical analysis

The study used the AHP hierarchical analysis [7,8] and calculated the index weights of urban amenity in Jiangsu based on the experts' scoring for each index. Then, a comprehensive evaluation index of urban amenity in Jiangsu was calculated based on the calculated urban amenity index weights, and the urban amenity was graded.

STEP 1. Calculation method of weights

The weight refers to the importance of the evaluation index in the evaluation system or the proportion of the evaluation index in the total score, and its quantity is expressed as the weight [9]. The experts construct a judgment matrix by scoring each indicator according to the value of the importance of the indicator weights and calculating the weights of the indicators at each level.

STEP 2. Dimensionless processing of the initial data

Averaging. First, find the sample mean value of each evaluation index, and then compare the actual value $X_i$ of the index with the mean value of the index to obtain the centralized evaluation value $Y_i$. The formula is as follows:

$$Y_i = X_i / X_0 \tag{1}$$

where $X_0$ is the average of the data.

STEP 3. Calculation formula of comprehensive evaluation index of urban amenity

Using the weighted stack method, multiply the three-level indices by their respective weights, and then sum up to obtain the comprehensive evaluation index of urban amenity. The calculation formula is as follows:

Comprehensive Evaluation Index of Urban Amenity

$$\sum_{i=1}^{n} w_i u_i \tag{2}$$

where $u_i$ is the original data of the third-level indicator; $w_i$ is the weight of the third-level indicator, and n is the number of items of the third-level indicator.

STEP 4. Spatial analysis using ArcGis

Use ArcMap software to draw the urban amenity level map according to the comprehensive evaluation index of urban amenity, and analyse the spatial differentiation of urban amenity.

### 3.3. Selection of Evaluation Indexes for Urban Amenity in Jiangsu

Combining the characteristics of the city, this paper constructs an urban amenity evaluation index system suitable for Jiangsu. The results are divided into 3 first-level indicators, 6 second-level indicators, and 17 third-level indicators (Figure 2).

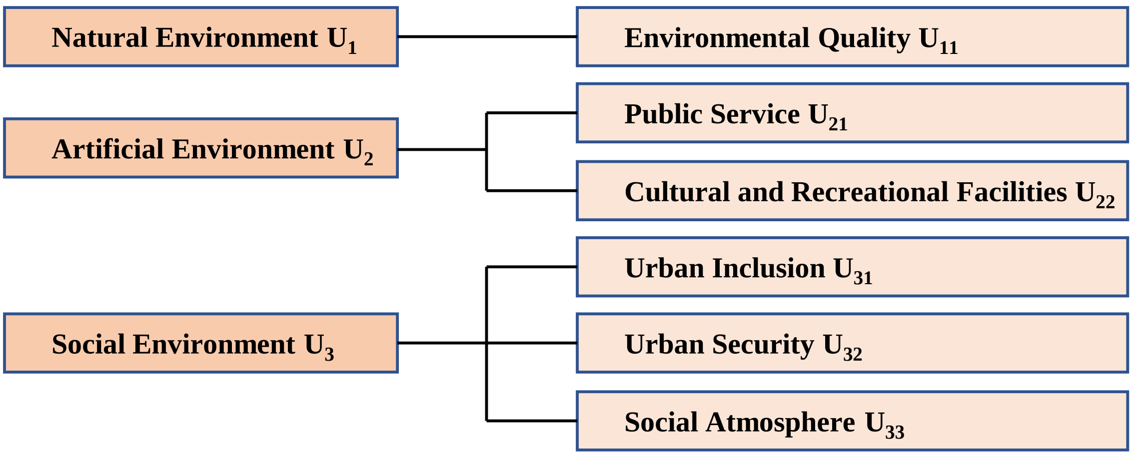


Figure 2 Evaluation index system.

## 4. Results

### 4.1. Comprehensive Evaluation of Urban Amenity

The determination of weights is a key part of the overall multi-index evaluation method. At present, the most commonly used methods for determining indicator weights are AHP [10,11], entropy method [12], principal component analysis [13], and mean square error decision method. These methods have their advantages in the comprehensive evaluation. However, considering a large number of indicators for evaluating urban amenity, the AHP is used to calculate the weight of the urban amenity index according to the scores of each index by experts. The weights in the comprehensive evaluation system are shown in Table 1.

Table 1 The Weight Index of the Comprehensive Evaluation of Urban Amenity.

| Level 1 Indicators | Weight Index | Level 2 Indicators | Weight Index | Level 3 Indicators | Weight Index |
|---|---|---|---|---|---|
| Natural Environment $U_1$ | 0.1429 | Environmental Quality $U_{11}$ | 0.1429 | $X_1$: Comprehensive air quality index | 0.0476 |
| | | | | $X_2$: Percentage of urban green space | 0.0476 |
| | | | | $X_3$: Percentage of urban water area | 0.0476 |
| Artificial Environment $U_2$ | 0.4286 | Public Service $U_{21}$ | 0.2143 | $X_4$: Ratio of primary and secondary school students to teachers | 0.0131 |
| | | | | $X_5$: Number of high-quality secondary schools per capita | 0.0131 |
| | | | | $X_6$: University student-teacher ratio | 0.0131 |
| | | | | $X_7$: Number of high-quality universities per capita | 0.0131 |
| | | | | $X_8$: Number of tertiary hospitals | 0.0507 |
| | | | | $X_9$: Health insurance coverage rate | 0.0507 |
| | | | | $X_{10}$: Density of urban road network | 0.0303 |
| | | | | $X_{11}$: Access rate to external transportation | 0.0303 |
| | | Cultural and Recreational Facilities $U_{22}$ | 0.2143 | $X_{12}$: Number of museums and theaters | 0.1071 |
| | | | | $X_{13}$: Number of restaurants, cafes, and supermarkets | 0.1072 |
| Social Environment $U_3$ | 0.4285 | Urban Inclusion $U31$ | 0.0607 | $X_{14}$: Social opinion participation and attitude | 0.0607 |
| | | Urban Security $U_{32}$ | 0.2248 | $X_{15}$: Crime rate | 0.1124 |
| | | | | $X_{16}$: Unemployment rate | 0.1124 |
| | | Social Atmosphere $U_{33}$ | 0.1430 | $X_{17}$: Educational level of residents | 0.143 |

### 4.2. Analysis of Spatial Differentiation of Urban Amenity

First, we used Equation 1 to perform dimensionless processing on the initial data and then used Equation 2 to calculate the comprehensive evaluation index of prefecture-level cities in Jiangsu. Then, the amenity of a city can be reasonably quantified, and the comprehensive evaluation index of urban amenity of the city can be determined according to the quantification, as shown in Table 2 Using the Natural Breaks (Jenks) in ArcMap (GIS software, Esri, Redlands, California, US), the amenity was divided into three categories, i.e., high amenity, medium amenity, and low amenity. Based on Table 2, the urban amenity level map (Figure 3) was obtained to analyze the spatial differentiation of urban amenity in cities.

Table 2 Comprehensive Evaluation Index of Urban Amenity in Jiangsu.

| Urban Amenity Level | City | Comprehensive Evaluation Index |
|---|---|---|
| First level High amenity | Suzhou | 0.684431 |
| | Nanjing | 0.657796 |
| | Wuxi | 0.634591 |
| Second level Moderate amenity | Changzhou | 0.568352 |
| | Zhenjiang | 0.545231 |
| | Yangzhou | 0.521594 |
| | Xuzhou | 0.499562 |
| | Nantong | 0.486625 |
| | Lianyungang | 0.468974 |
| | Taizhou | 0.433256 |
| Third level Low amenity | Huai’an | 0.381388 |
| | Yancheng | 0.358779 |
| | Suqian | 0.343856 |

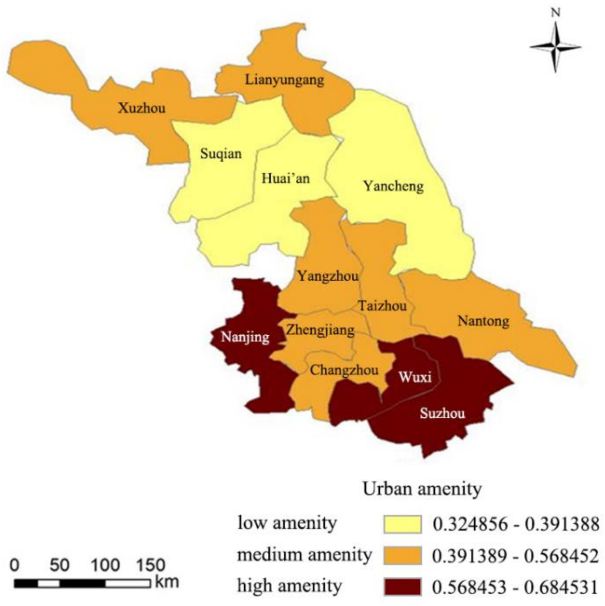


Figure 3 Urban amenity level analysis chart of Jiangsu.

It can be seen from Figure 3 that the 13 prefecture-level cities can be divided into three levels. Among them, Suzhou, Nanjing, and Wuxi are three cities with high amenity, and the comprehensive evaluation index is between 0.568453~0.684531. Seven cities including Changzhou, Zhenjiang, Yangzhou, Xuzhou, Nantong, Lianyungang, and Taizhou have moderate amenity, with a comprehensive evaluation index ranging from 0.391389 to 0.568452. The three cities of Huai'an, Yancheng, and Suqian are low in amenity, and the comprehensive evaluation index is between 0.324856~0.391388. The urban amenity level analysis chart more objectively reflects the urban amenity status. The average development of Suzhou, Nanjing, and Wuxi is better and more uniform, and the infrastructure is better, so the urban amenity is higher. In general, the spatial distribution of urban amenity in Jiangsu presents a certain law. Cities with high amenity are mainly distributed in the economically developed southern Jiangsu area, and cities with low amenity are mainly distributed in northern Jiangsu. This mainly corresponds to the economic development level of Jiangsu cities in terms of spatial distribution. Urban amenity differs significantly, basically showing a regional distribution pattern of south, central and north Jiangsu in a descending order.

## 5. Conclusions

In this study, we used AHP to construct the urban amenity index weights and graded the urban amenity using the comprehensive urban amenity evaluation index. The results showed that Suzhou, Nanjing, and Wuxi are high amenity cities, Changzhou, Zhenjiang, Yangzhou, Xuzhou, Nantong, Lianyungang, and Taizhou are medium amenity cities, and Huai'an, Yancheng, and Suqian are low amenity cities. Through the above analysis, the geographical migration of talents plays a decisive role in urban amenity. Therefore, the governments should try the best to attract talents and attract high-tech industries and capital through the gathering of talents, so as to develop the urban economy and improve the development potential of the city.

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